

# **Pinyon Jay (*Gymnorhinus cyanocephalus*): A Technical Conservation Assessment**



**Prepared for the USDA Forest Service,  
Rocky Mountain Region,  
Species Conservation Project**

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## COVER PHOTO CREDIT

Pinyon jay (*Gymnorhinus cyanocephalus*), courtesy of the photographer, Glen Tepke.

## SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF THE PINYON JAY

Pinyon jays (*Gymnorhinus cyanocephalus*) occur in low-elevation conifer woodlands (primarily pinyon-juniper) throughout much of the interior western United States. Although they have been closely studied in northern Arizona and central New Mexico, their ecology is virtually unstudied in other portions of their range. Pinyon jays are highly social, living year-round in flocks composed of groups of closely related individuals. In fall and winter, flocks may disperse widely in search of their principal food source, pine seeds. Pinyon jays and pinyon pine (*Pinus edulis*) have coevolved, with jays depending on pinyon pine seeds as their primary food source in fall and winter, and also acting as dispersal agents for the seeds.

Due to perceived long-term population declines in some areas, pinyon jays are considered a Species of Conservation Concern by the U.S. Fish and Wildlife Service within the Southern Rockies/Colorado Plateau Bird Conservation Region. They are also on the National Audubon Society's Watch List and the Partners in Flight National Watch List. There has been growing concern recently over the fate of pinyon jays in the southwestern states (including Colorado) given the ongoing, widespread die-off of pinyon pines in the region. Severe drought over several years appears to have induced water stress in pinyon pines, making them more susceptible to attack by pinyon engraver beetles (*Ips confusus*). Compounding the current *Ips* infestation is the fact that beetles typically attack older, more mature pinyon trees, which are the primary cone producers and thus a principal source of food for pinyon jays. During such infestations, large areas may be severely affected, with up to 90 percent mortality of the local pinyon pine population.

Historically, a significant threat to pinyon jay populations has been the widespread clearing of pinyon-juniper woodland in the Southwest, primarily for conversion to habitat more suitable to livestock grazing. However, federal agency support for such habitat destruction appears to no longer be in force. In recent years, the National Fire Plan has led to severe reductions in the density of pinyon-juniper woodlands in some areas, and thus represents a new, potential threat to the quality of pinyon jay habitat. The attitude that pinyon-juniper woodlands are of "no commercial value" has led to ongoing exploitation, including clearing, logging (primarily for firewood and Christmas trees), and commercial development. Fire suppression may also negatively impact jay populations, as it may result in a heavy fuels buildup, leading to large, intense wildfires. In addition, fire suppression typically leads to decreased local vegetative diversity and may therefore negatively affect food supplies. In some situations, small-scale fires and woodland clearing may benefit jays by increasing habitat diversity, reducing the chances of large-scale fires, and contributing to woodland regeneration.

Recent census work in Colorado has shown a close association between pinyon jays and pinyon-juniper woodlands. Consequently, the ongoing loss of mature pinyon trees throughout southern and western Colorado represents a serious threat to the long-term stability of pinyon jays in that region. Research on the impacts of the pinyon pine die-off on pinyon jay ecology would assist land managers in formulating habitat management strategies that may assist jay populations, as well as other species of birds (e.g., juniper titmouse [*Baeolophus griseus*], gray vireo [*Vireo vicinior*], black-throated gray warbler [*Dendroica nigrescens*]) that are pinyon-juniper obligates.

Currently, there is little information available on the ecology of pinyon jays within USDA Forest Service Region 2. Although the species has been relatively well-studied, those studies have occurred in Arizona and southwestern New Mexico where habitat differs from that in Region 2. Consequently, the primary information needed for the successful management of pinyon jays in Region 2 is a better understanding of the species' ecology in the region. Data on the size of and habitats within home ranges, nest site characteristics, reproductive success, and seasonal movements would be particularly useful. Land managers would clearly benefit from studies assessing the effects of changes in habitat quality (e.g., due to *Ips* infestation or to woodland thinning) on the ecology of local pinyon jay flocks.

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## INTRODUCTION

This conservation assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2), USDA Forest Service (USFS). Until recently, the pinyon jay (*Gymnorhinus cyanocephalus*) was a Management Indicator Species (MIS) on at least one forest in Region 2 (**Figure 1**). Although it no longer has formal management status within Region 2 of the Forest Service, the apparent long-term declines recorded for pinyon jay, as well as the pronounced die-off of pinyon pine (*Pinus edulis*) in Colorado raise concern for this species in southern portions of the region. Consequently, this assessment may be an important resource for land managers of pinyon-juniper habitats, particularly those in Colorado that are experiencing widespread pinyon pine mortality, to assist in developing strategies for conserving a species that will in all probability be heavily impacted by the ongoing loss of pinyon pine woodland habitat. This assessment addresses the

biology, ecology, conservation and management of the pinyon jay throughout its range, but with an emphasis on Region 2. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

### Goal

Species conservation assessments produced as part of the Species Conservation Project are designed to provide land managers, biologists, and the public with a thorough discussion of the biology, ecology, implications of land management, and conservation of certain species based on current scientific knowledge. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop prescriptive management recommendations. Rather, it provides the ecological background upon which management must be based and focuses on the

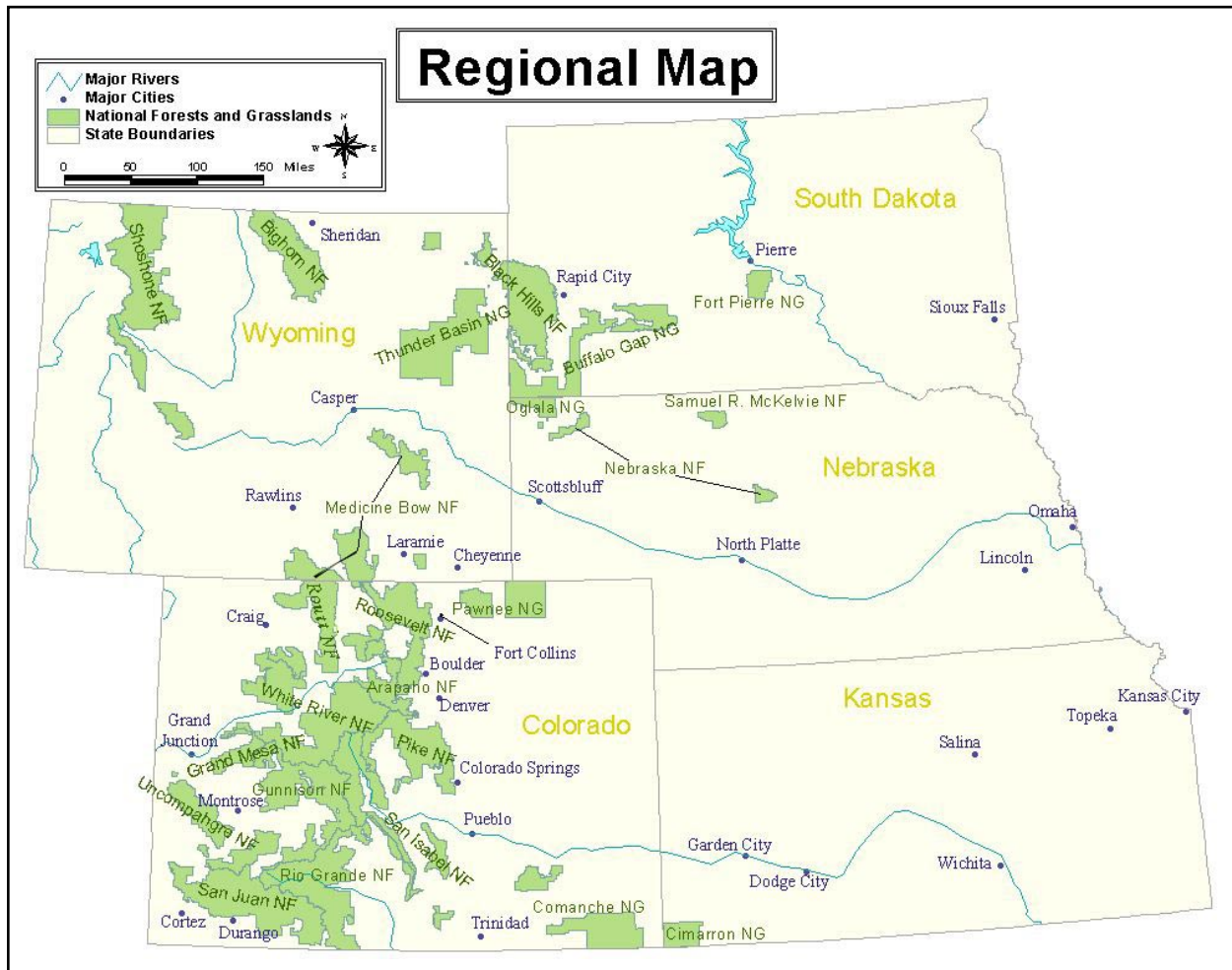


Figure 1. Map of the national forests and grasslands within USDA Forest Service Region 2.

consequences of changes in the environment that result from management (i.e., management implications). This assessment also discusses management recommendations proposed elsewhere and examines the success of those management strategies implemented.

### ***Scope and Limitations of Assessment***

The pinyon jay assessment examines the biology, ecology, conservation, and management of this species with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Although a majority of the literature on the species originates from field investigations outside the region (primarily northern Arizona), this document attempts to place that literature in the ecological and social context of the central and southern Rockies. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of pinyon jays in the context of the current environment. The evolutionary environment of the species is considered in conducting the synthesis, but placed in current context.

In producing the assessment, I reviewed refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies. Not all publications on pinyon jays are referenced in the assessment, nor were all published materials considered equally reliable. The assessment emphasizes refereed literature because this is the accepted standard in science. Non-refereed publications or reports were used when the author believed they contributed to the assessment, but these were regarded with greater skepticism.

### ***Treatment of Uncertainty***

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, strong inference, as described by Platt, suggests that experiments will produce clean results (Hillborn and Mangel 1997), as may be observed in certain physical sciences. The geologist, T. C. Chamberlain (1897) suggested an alternative approach to science where multiple competing hypotheses are confronted with observation and data. Sorting among alternatives may

be accomplished using a variety of scientific tools (e.g., experiments, modeling, logical inference). In some ways, ecological science is similar to geology because of the difficulty in conducting critical experiments and the reliance on observation, inference, and models to guide understanding of the world (Hillborn and Mangel 1997).

Confronting uncertainty, then, is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and when appropriate, alternative explanations are described. While well-executed experiments represent a strong approach to developing knowledge, alternative approaches such as modeling, critical assessment of observations, and inference are accepted as sound approaches to understanding.

### ***Publication of Assessment on the World Wide Web***

To facilitate use of species conservation assessments, they are being published on the Region 2 World Wide Web site. Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, it facilitates their revision, which will be accomplished based on guidelines established in Region 2.

### ***Peer Review***

Assessments developed for the Species Conservation Project have been peer reviewed prior to their release on the Web. This report was reviewed through a process administered by the Society for Conservation Biology employing at least two recognized experts on this or related taxa. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

## **MANAGEMENT STATUS AND NATURAL HISTORY**

### ***Management Status***

A number of regional and national conservation organizations have listed the pinyon jay as a species of conservation concern. It has recently been listed as a "Bird of Conservation Concern" by the U.S. Fish and Wildlife Service within Bird Conservation Region 16 (Southern Rockies/Colorado Plateau; U.S. Fish and Wildlife Service 2002). The pinyon jay is also included on the Audubon Society's 2002 Watch List (yellow priority; <http://audubon2.org/webapp/watchlist/>)

viewWatchlist.jsp) and on the Partners in Flight (PIF) National Watch List (as “Threatened and declining”; [http://www.abcbirds.org/pif/pif\\_watch\\_list.htm](http://www.abcbirds.org/pif/pif_watch_list.htm)). A summary of the management status of this species within state PIF Bird Conservation Plans is presented in **Table 1**. The pinyon jay is listed as a Priority Species in the Colorado PIF plan (Beidleman 2000), but it is only a Level IV species (populations do not appear to be declining) in the Wyoming PIF plan (Nicholoff 2003). PIF plans for other states within Region 2 have not been

published. Outside of Region 2, the pinyon jay is listed as High Priority species in Idaho and New Mexico, and as a Priority species in Nevada and Arizona (**Table 1**). No state Natural Heritage Programs within Region 2 assign a management status rank to the pinyon jay; however, the species is listed as imperiled in Oklahoma (**Table 2**). The pinyon jay currently has no formal management status within either the USFS or Bureau of Land Management in Colorado or Wyoming.

**Table 1.** Management status of pinyon jays within Partners in Flight (PIF) state Bird Conservation Plans. Region 2 states are in bold.

State	Status	Citation
<b>Colorado</b>	Priority Species	Beidleman 2000
<b>Kansas</b>	State PIF plan not published	
<b>Wyoming</b>	Not a Priority Species, but a Level IV* species	Nicholoff 2003
<b>Nebraska</b>	State PIF plan not published	
<b>South Dakota</b>	State PIF plan not published	
Montana	Not a Priority Species	Casey 2000
New Mexico	High Responsibility Priority Species	Rustay 2001
Utah	Not a Priority Species	Parrish et al. 2002
Idaho	High Priority Species (Juniper/Pinyon/Mt. Mahogany forest)	Ritter 2000
Nevada	Priority Species	Neel 1999
Oregon	Not a focal species	<a href="http://community.gorge.net/natres/pif/con_plans/columbia_plan.html">http://community.gorge.net/natres/pif/con_plans/columbia_plan.html</a>
California	Not a focal species	<a href="http://www.prbo.org/calpif/data.html">http://www.prbo.org/calpif/data.html</a>
Arizona	Priority Species (pinyon-juniper woodlands)	Latta et al. 1999

\*Level IV species are species of concern, but whose populations are thought to be stable or increasing.

**Table 2.** State-based management status of pinyon jays within USDA Forest Service Region 2 (in bold) and surrounding states. State ranks are typically determined by state Natural Heritage Programs.

State	State Rank	Date accessed or publication date	Reference
<b>Wyoming</b>	Not listed	February 2004	<a href="http://www.uwyo.edu/wyndd">www.uwyo.edu/wyndd</a>
<b>South Dakota</b>	Not listed	15 March 2002	<a href="http://www.state.sd.us/gfp/Diversity/RareAnimal.htm">http://www.state.sd.us/gfp/Diversity/RareAnimal.htm</a>
<b>Colorado</b>	Not listed	May 1999	<a href="ftp://ftp.cnhp.colostate.edu/99Handbook.pdf">ftp://ftp.cnhp.colostate.edu/99Handbook.pdf</a>
<b>Nebraska</b>	Not listed	May 1996	<a href="http://www.natureserve.org/nhp/us/ne/birds.html">http://www.natureserve.org/nhp/us/ne/birds.html</a>
Kansas	Not listed	July 2000	<a href="http://www.kbs.ukans.edu/">http://www.kbs.ukans.edu/</a>
Nevada	SC <sup>1</sup>	February 2004	<a href="http://dcnr.nv.gov/nrp01/bio04.htm">http://dcnr.nv.gov/nrp01/bio04.htm</a>
Oklahoma	S2 <sup>2</sup>	January 2003	<a href="http://www.biosurvey.ou.edu/pub/animals01.pdf">http://www.biosurvey.ou.edu/pub/animals01.pdf</a>
Montana	Not listed	August 2001	<a href="http://nhp.nris.state.mt.us">http://nhp.nris.state.mt.us</a>
Utah	Not listed	February 1998	Utah Div. Wildlife Resources, February 1998
Arizona	S5 <sup>3</sup>	August 2002	<a href="http://www.gf.state.az.us/frames/fishwild/hdms_site/SpeciesLists/htm">www.gf.state.az.us/frames/fishwild/hdms_site/SpeciesLists/htm</a>
New Mexico	Not listed	January 2002	<a href="http://www.gmfsh.state.nm.us">http://www.gmfsh.state.nm.us</a>

<sup>1</sup>SC = Species of concern, as ranked by 0state Partners in Flight bird conservation plan.

<sup>2</sup>S2 = = Imperiled because of rarity or because of some other factor(s) making it vulnerable throughout its range.

<sup>3</sup>S5 = Demonstrably secure; may be rare in parts of range, particularly at periphery.

### ***Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies***

Pinyon jays are protected under the Migratory Bird Treaty Act, but there are currently no published management plans or conservation strategies directed solely at pinyon jays. Several PIF state and regional plans have included management recommendations for pinyon jays and an overview of these recommendations is provided in **Table 3**. The primary management recommendation is that the common practice of

chaining, cutting, and otherwise destroying pinyon-juniper woodlands be halted. In many locales, pinyon-juniper woodlands have been eliminated or degraded in order to increase foraging area for livestock grazing, and to provide for local collection of firewood.

### ***Biology and Ecology***

#### **Systematics**

There is relatively little geographic differentiation in pinyon jays, with the size and shape of the bill

**Table 3.** A selection of management recommendations for pinyon jays in Partners in Flight state Bird Conservation Plans. Region 2 state is in bold.

<b>State</b>	<b>Recommendations</b>	<b>Presumed benefits</b>	<b>Citation</b>
<b>Colorado</b>	Manage woodlands to provide for large, mature trees	Provide preferred foraging and nesting habitat	Beidleman 2000
	Discourage road-building near traditional nesting areas	Reduce likelihood of colony abandonment	
Nevada	Maintain mature pinyon trees	Maintain preferred foraging and nesting habitat	Neel 1999
	Discourage cutting of mature trees for fuel wood	Maintain preferred foraging and nesting habitat	
	Determine age structure of pinyon stands and presence of jays in those stands	Identify optimal habitats	
	Analyze projected pinyon-juniper treatment projects and assess the impacts of such treatments on pinyon jay populations	Plan for future mitigation activities	
Arizona	Maintain extensive stands of mature (>75 years) pinyon	Maintain preferred breeding habitat	Latta et al. 1999
	Limit collection of cone-producing pinyon trees for fuelwood	Reduce habitat loss	
	Identify and retain traditional home range habitats	Maintain habitat within traditional home ranges	
	Inventory the structural-stage distribution of local pinyon-juniper to determine the % of mature stands	Better understanding of woodland suitability	
	Reduce <i>Ips</i> beetles by reducing the number of slash piles	Decrease damage/loss of trees from beetle attacks	
	Encourage small-scale openings in mature woodlands	Optimize habitat structure	
	Do not overgraze livestock	Decrease soil erosion	
	In areas with heavy raven predation at nests, consider local raven control measures	Increase local nesting success	
New Mexico	Maintain 6 contiguous non-fragmented blocks of 500 acres each within 5000 acre blocks	Maintain optimal habitat suitability	Rustay 2001

varying from short and thin in the northern part of the range, to long and broad in the Southwest (Brodkorb 1936, Overholser 1974). Although some authors have recognized three subspecies (Brodkorb 1936, Overholser 1974, Phillips 1986, Pyle 1997), the American Ornithologists' Union (1957) did not recognize them.

#### Distribution and abundance

Within Region 2, pinyon jays are largely restricted to mid-elevation (4,500 to 7,500 feet, 3,500 to 4,500 feet in the Black Hills) pinyon (*Pinus edulis*)-juniper (*Juniperus* spp.), juniper, and ponderosa pine (*P. ponderosa*) woodlands. Although these habitats are widely distributed throughout the western United States, pinyon jays breed in a relatively patchy pattern within their range (Balda 2002). There has been little apparent change in the distribution of pinyon jays, but some concern has surfaced over declining abundance in recent years. In Arizona and other areas in the southwestern United States, former government-sponsored pinyon-juniper eradication programs appear to have contributed to local declines in pinyon jays (Balda 2002).

The breeding distribution of pinyon jays (**Figure 2**) includes: south-central and southeastern Montana (Montana Bird Distribution Committee 1996); northern, central, and south-central Wyoming (Dorn and Dorn 1999); western South Dakota (Tallman et al. 2002), northwestern Nebraska (where breeding is possible; Mollhoff 2001, Sharpe et al. 2001); southeastern Idaho (Burleigh 1972); central Oregon (Marshall et al. 2003); eastern and southern California (Garrett and Dunn 1981, Small 1994); most of Nevada (Alcorn 1988) and Utah (Hayward et al. 1976); western and southern Colorado (Andrews and Righter 1992, Dexter 1998); extreme northwestern Oklahoma (Sutton 1967); northern and central New Mexico (Hubbard 1978); and northern Baja California, Mexico (Howell and Webb 1995).

Balda (2002) summarized the historical changes in pinyon jay populations, concluding that large-scale pinyon-juniper eradication programs carried out from the 1940's to the 1960's likely caused significant mortality and localized extirpations. However, no good quantitative data are available on local population declines, and conclusions are difficult to draw given that pinyon jays may move over large distances within their preferred habitat and thus may be difficult to monitor over time.

#### *Regional distribution and abundance*

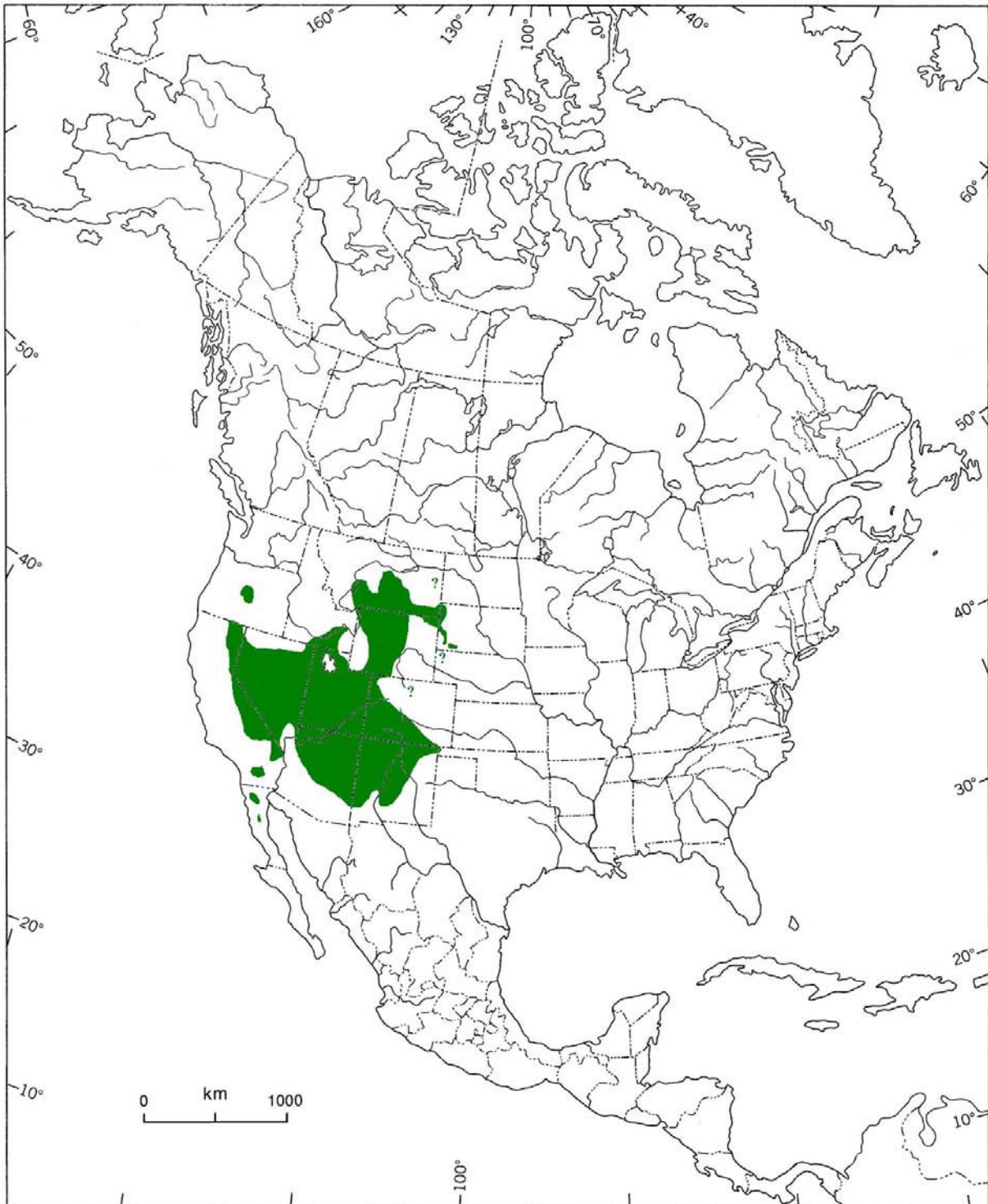
Within Region 2, pinyon jays are found in Colorado, Wyoming, and South Dakota, with occasional birds wandering into northwestern Nebraska and southwestern Kansas. Their current status in Region 2 is as follows:

**South Dakota:** "Common permanent resident at lower elevations from 3,500 to 4,500 feet elevation" in the Black Hills (Pettingill and Whitney 1965). It is resident in open pine forest in the Black Hills, as well as Harding and Shannon counties (Tallman et al. 2002). The South Dakota Breeding Bird Atlas project found pinyon jays mainly in the southwestern corner of the state, with one record in the northwest (Harding County; Peterson 1995).

**Nebraska:** Pinyon jays apparently bred in the northwestern corner of the state during the 1800's (Bates 1900), but there are no confirmed breeding records since 1900 (Sharpe et al. 2001). Despite several spring and summer records of pinyon jays in the northwestern pine woodlands (e.g., Ducey 1988), including sightings of recently fledged young, Sharpe et al. (2001) concluded that there was no firm evidence of breeding within the state, and that jays likely wander south from breeding areas in South Dakota. However, based upon data collected during the Nebraska Breeding Bird Atlas effort (1984-1989), Mollhoff (2001) considered it likely that at least two sightings of adults feeding young (in Scotts Bluff and Sioux counties) were of birds of local origin. Clearly, the breeding status of pinyon jays in Nebraska needs further study.

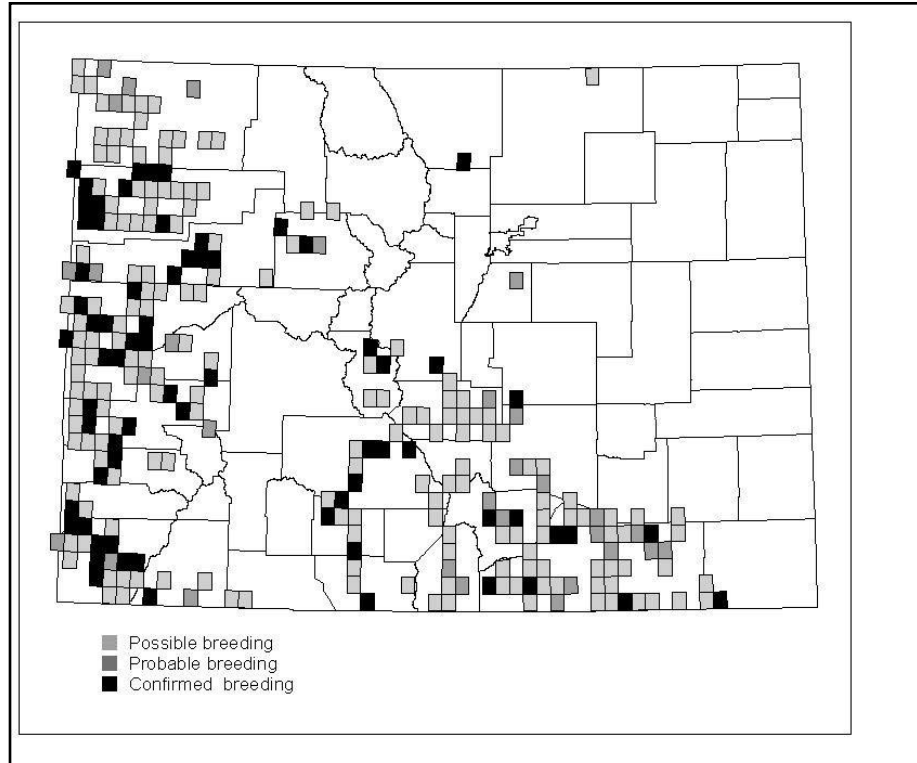
**Wyoming:** Pinyon jays are widespread residents in Wyoming, occurring in most areas that support pinyon-juniper and ponderosa pine woodlands. The only areas in the state where they are not known to breed are the heavily forested western tier of counties, the low-elevation scrub habitat in the central portion of the state, and the grasslands of the southeast (Dorn and Dorn 1999).

**Colorado:** In Colorado, pinyon jays are permanent residents of pinyon-juniper woodlands throughout western, central, and southern Colorado (Andrews and Righter 1992). The recent Colorado Breeding Bird Atlas project documented breeding south of a line from the northwestern to the southeastern corner of the state (**Figure 3**; Dexter 1998). However, the distribution and abundance within this range was patchy, with jays concentrated along the western third and the south-central portions of the state.

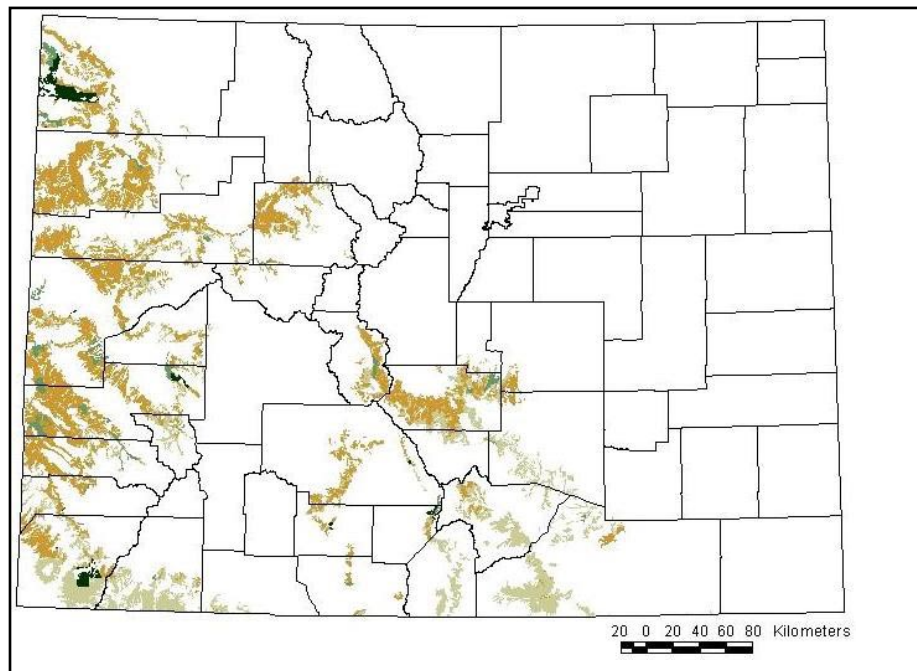


**Figure 2.** Map of the breeding range of pinyon jays in North America. The figure was modified from data provided in Balda (2002).

(A)



(B)



**Figure 3.** Comparison of the distribution of pinyon jays (upper figure) and pinyon juniper woodlands (lower figure) in Colorado. The upper map was reproduced from the Colorado Breeding Bird Atlas (Kingery 1998) with the permission of the Colorado Bird Atlas Partnership, from a digitized version provided by the Rocky Mountain Bird Observatory. The pinyon juniper map is from the Colorado Natural Heritage inventory web site. Different colors on the pinyon juniper map reflect land stewardship (green = National Park/Monument, orange = Forest Service/BLM, beige = state, tribal or private).

**Kansas:** Pinyon jays are occasional fall and winter visitors to southwestern Kansas, but they have not been recorded breeding in the state (Thompson and Ely 1989).

#### *Regional discontinuities in distribution and abundance*

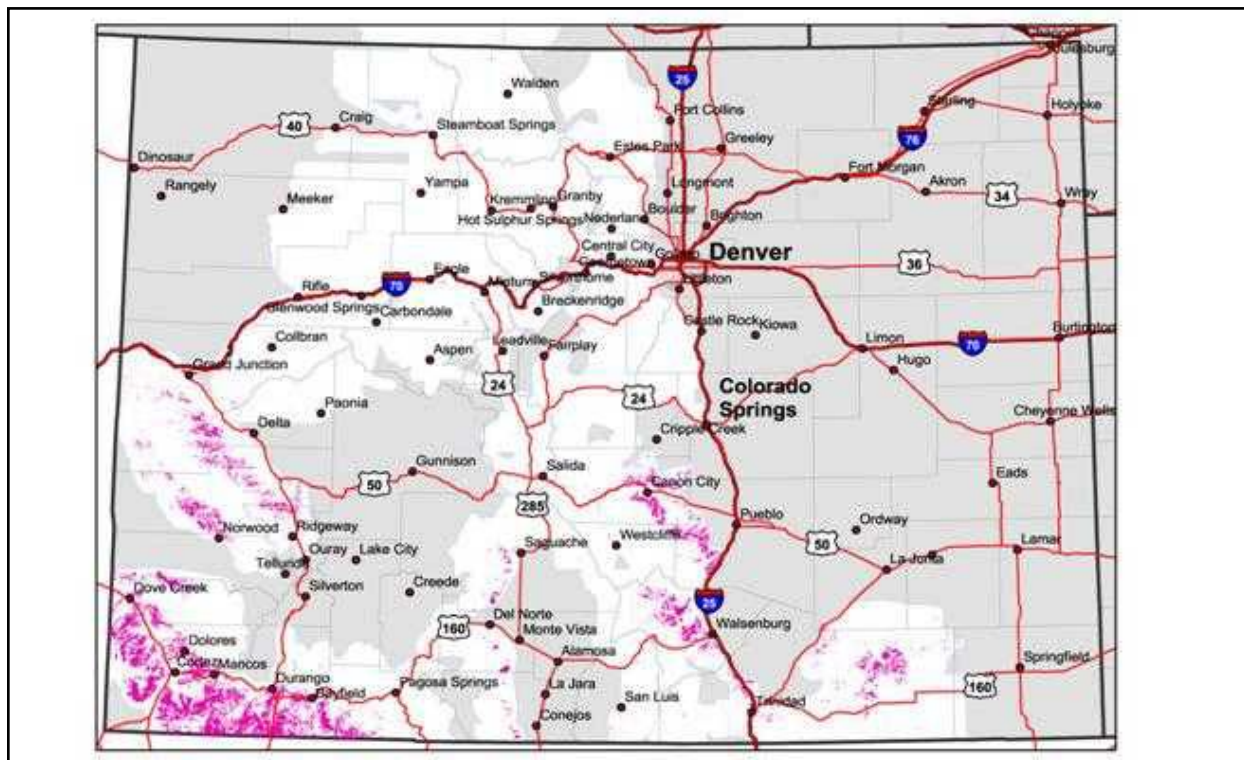
As noted previously, pinyon jays are patchily distributed throughout their North American range. They are restricted to low to mid-elevation conifer (primarily pinyon-juniper, juniper, and ponderosa pine) woodlands. In addition, their distribution may shift within their home range, depending on the availability of pine seeds. There have been no apparent historical shifts in distribution in Region 2, with the exception that they may no longer breed in northwestern Nebraska (Ducey 1988, Sharpe et al. 2001; but see Mollhoff 2001). Local abundance is often difficult to measure, as flocks are very mobile and may move considerable distances in search of food.

#### Population trend

Balda (2002) stressed the difficulty in censusing pinyon jays and concluded that there were no reliable

methods available to accurately determine population status on a local or regional scale. This presents a major problem for this species, especially in light of the recent widespread die-off of pinyon pine trees in Colorado and the Southwest (**Figure 4**). Without a reliable census protocol, it will be impossible to gauge the effects of this die-off on pinyon jay populations. Thus, development of a census protocol should rank as a critical priority for future studies of pinyon jay population status (see the Information Needs section).

Data from the North American Breeding Bird Survey (BBS; Sauer et al. 2003) on long-term trends in pinyon jay abundance are summarized in **Table 4**. Pinyon jays may initiate breeding from February to July, and thus some early breeding birds may be missed during BBS surveys in May and June. Nonetheless, the BBS data provide one of the only rangewide indications of long-term population trends (the other being Christmas Bird Count data – see below). The general pattern from the BBS data from Region 2 is that pinyon jay abundance has declined slightly in Wyoming but has decreased strongly in Colorado in recent years. A strong decrease has also been noted in South Dakota since 1980, but the number of sampling routes there is very low ( $n = 2$ ). Outside of Region 2, population trends



**Figure 4.** The occurrence of pinyon pine beetle (*Ips confusus*) infestation (pink areas) in pinyon-juniper woodlands of Colorado in 2003. Data were derived from aerial surveys. The light gray background indicates areas that were not surveyed. Note the extensive pinyon mortality in the southwestern corner of the state.

**Table 4.** Table 4. Pinyon jay population trend results from North American Breeding Bird Surveys from 1966 to 2002, from Sauer et al. (2003). Region 2 states are in bold. Trend indicates the percentage change per year, while N indicates the number of survey routes used. Underlined P values are statistically significant.

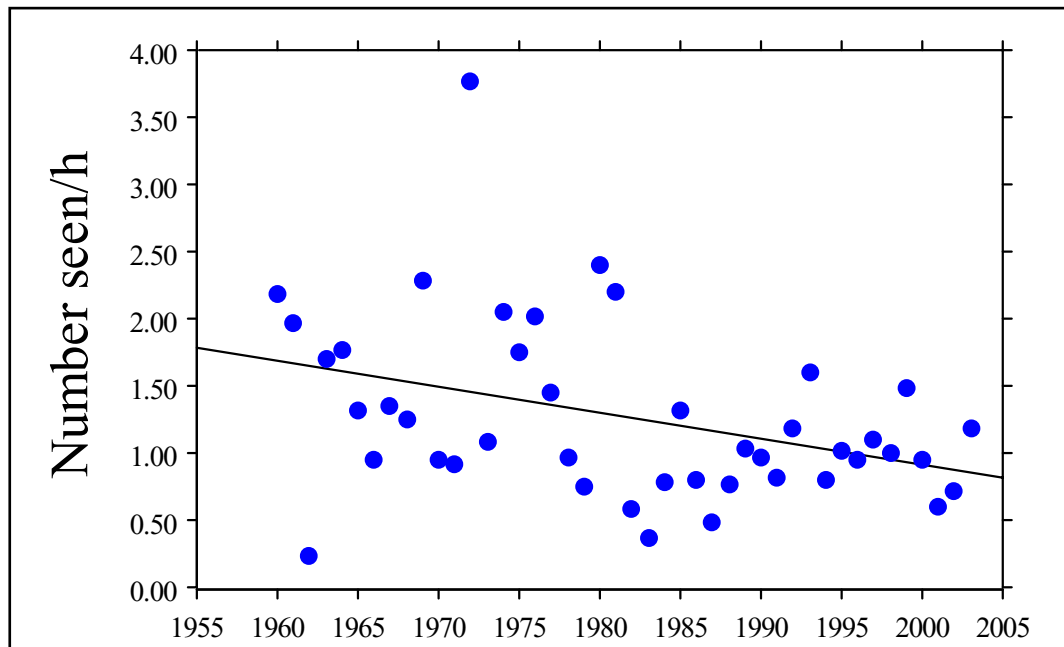
Region	1966-1979			1980-2002			1966-2002		
	N	Trend	P	N	Trend	P	N	Trend	P
<b>South Dakota</b>	—	—	—	2	-15.9	0.06	2	-7.4	0.36
<b>Wyoming</b>	2	130.3	0.26	7	-1.5	0.77	9	-0.7	0.86
<b>Colorado</b>	3	5.1	0.14	32	-10.5	<u>0.00</u>	32	-7.2	<u>0.00</u>
Arizona	4	-14.9	0.15	15	-3.4	0.21	18	-4.8	0.44
Utah	5	43.2	<u>0.18</u>	40	0.9	0.81	42	-1.1	0.73
New Mexico	12	-2.0	0.27	29	-3.9	0.26	30	-4.4	0.07
Montana	4	8.1	<u>0.02</u>	8	-0.5	0.86	8	-0.6	0.85
Nevada	7	-28.5	<u>0.00</u>	13	-7.7	0.21	16	-10.7	<u>0.01</u>
California	10	-23.3	<u>0.00</u>	12	1.8	0.06	15	-7.3	<u>0.00</u>
United States	49	-8.9	<u>0.02</u>	163	-4.3	<u>0.03</u>	178	-4.5	<u>0.00</u>

have largely been negative across the species' range (**Table 4**). Christmas Bird Count (CBC) data, collected annually between mid-December and early January, also show a significant, long-term decline within Region 2 as a whole (**Figure 5**).

#### Activity pattern and movements

Pinyon jays breed in loose colonies and tend to use the same general nesting site from year to year (Balda

2002). During the breeding season, adults typically forage together within their flock's home range, which averages 23 km<sup>2</sup> in northern Arizona (Marzluff and Balda 1992). Pinyon jays normally cache pine seeds in leaf/needle litter below trees, next to fallen trees, or next to rocks (Ligon 1978). Cache sites tend to be in areas of open habitat with scattered trees and, consequently, jays act as key dispersal agents for seeds into areas (e.g., chained pinyon-juniper woodland) that are often optimally situated for new growth (Ligon 1978). In



**Figure 5.** Long-term trend in pinyon jay abundance on Christmas Bird Counts in USDA Forest Service Region 2 (Colorado, South Dakota, and Wyoming only). The regression line is for illustrative purposes only. The negative trend is significant (Spearman rank correlation,  $r_s = -0.38$ ,  $P = 0.013$ ,  $n = 44$ ).

some cases, jays may fly up to 11 km to cache seeds that they carry in their expandable esophagus. Ligon (1978) reported a pinyon jay carrying 56 pinyon seeds in its esophagus while caching in January.

Pinyon jays typically remain on or near their home range throughout the year, regularly visiting cache sites and foraging areas. However, in years of poor pine cone crops, flocks may roam widely. Balda (2002) cited widespread irruptive movements in 1914, 1950, 1955, 1961, 1972, 1978, 1990, and 2000. During the winter of 2002-2003, pinyon jays were unusually common and widespread on the eastern limits of their range in southeastern Colorado and the extreme northwestern Oklahoma panhandle, with some flocks wandering eastward onto the plains (D. Wiggins, personal observation). During such “invasions”, jays may be found in atypical habitats, such as riparian woodlands along the western Great Plains (Cable et al. 1996). These irruptive movements normally begin in August or September, with most individuals returning to their home territories in February (Balda 2002).

During the fall, when flocks tend to roam more widely, some flock switching typically occurs. Immigrants are normally juvenile females, with juvenile males typically remaining in their natal flocks. Thus, in areas where pinyon jays are relatively common, neighboring populations appear to be well-linked, with limited immigration occurring on a regular basis. Greater than 80 percent of all young remain in their natal flock, and of those young that do move, most join neighboring flocks 3 to 30 km away from their natal site. Long-distance movements by pinyon jays are rare. Marzluff and Balda (1989) cited only two of 170 band returns that involved long-distance movements – one individual that was banded in north-central Arizona and recovered 600 km east in New Mexico, and another that was banded in western South Dakota and recovered 640 km west in Montana.

## Habitat

### *Nesting habitat*

Although pinyon jays are often described as pinyon-juniper woodland obligates, habitat choice varies across the species’ range. In areas where pinyon-juniper does not occur, pinyon jays occupy other habitats including ponderosa and Jeffrey (*Pinus jeffreyi*) pine, sagebrush (*Artemisia* spp.), scrub oak (*Quercus* spp.), and chaparral. However, at least in the core of the species’ range, the vast majority of flocks occur within or near pinyon-juniper habitats (Balda 2002).

The precise habitats chosen as nesting sites have rarely been quantified, as colony sites can be difficult to find due to the secretive nature of the birds, as well as to their early nesting habits. In northern Arizona, pinyon jays nested in ponderosa pine at relatively high elevation, and in pinyon pine and junipers at lower elevations (Gabaldon 1978). In Colorado, pinyon jays only rarely use ponderosa pine forests for nesting; only 2 percent of confirmed breeding records during the Colorado Breeding Bird Atlas project were in ponderosa pine, with 96 percent having occurred in pinyon-juniper (Dexter 1998). The distribution of pinyon jays, as found during the Colorado Breeding Bird Atlas, very closely mirrors the distribution of pinyon-pine habitat in the state (**Figure 3**). In Wyoming, Scott (1993) described pinyon jay breeding habitat as ponderosa pine and juniper. In South Dakota, pinyon jays occur primarily in open ponderosa pine forests (Panjabi 2004a).

Further west in their range, pinyon jays occur outside the range of pinyon-juniper habitat. In central Oregon, for example, they occur in juniper, and juniper-ponderosa pine transition habitats (Marshall et al. 2003). In California, pinyon jays also inhabit Jeffrey pine woodlands (Grenfell and Laudenslayer 1983).

No empirical studies have quantified habitat use by nesting jays in Region 2 – that is, nesting habitats are typically presumed based upon sightings of birds during the spring. Given the shift in habitat use from southern Colorado (pinyon-juniper) to Wyoming and South Dakota (juniper and ponderosa pine), there is a clear need for data on the habitats chosen for colony sites/home ranges.

### *Wintering habitat*

As pinyon jays tend to remain on their home territories year-round, wintering habitat is similar to breeding habitat. In some years, however, jays may wander during the fall and early winter to nearby habitats, including ascents into montane mixed-conifer forests to feed on limber (*Pinus flexilis*) and bristlecone pine (*P. aristata*) seeds (Dawson 1923, Balda 2002). They may also visit any caching sites outside their traditional home range. As mentioned elsewhere in this assessment, pinyon jays occasionally also wander to low elevation riparian areas during fall and winter, especially during years of poor pine seed crops.

### *Foraging habitat*

Pinyon jay foraging habitats have not been well-quantified, likely as a result of their strong flight

capabilities and high mobility, which makes following flocks extremely difficult. Pinyon jays generally forage in the same habitats that they utilize for breeding, that is, pinyon-juniper and ponderosa pine woodlands, as well as nearby open habitats such as grasslands, sagebrush areas, and open ponderosa pine woodlands (Balda 2002). In extreme northwestern Oklahoma, pinyon jays typically are seen foraging in open pinyon-juniper woodland, as well as in intervening patches of dry shrubland (D. Wiggins, personal observation). In northern Arizona, flocks may range into suburban areas where bird feeders supply year-round food (Marzluff and Balda 1992); the extent to which this occurs in Region 2 is not known.

### Food habits

Although pinyon jays are omnivores, their primary food during the fall, winter, and spring appears to be pine seeds, especially pinyon pine seeds. Pinyon jays and pinyon pines have coevolved, with jays consuming huge quantities of pinyon seeds each year, and also acting as dispersal agents for the seeds (Ligon 1978). Jays extract seeds and cache them, usually amid litter on the ground, but also within tree crevices and clusters of pine needles. Although pinyon jays show a high degree of accuracy in recovering cached seeds (Balda and Kamil 1998), some caches are not recovered, and thus pinyon seeds are spread throughout the landscape. Pinyon jays are the primary dispersal agents for pinyon seeds, with smaller numbers of seeds dispersed by western scrub-jays (*Aphelocoma californica*; Balda 2002). In the southwestern United States, including southern and western Colorado, the degree to which pinyon jay flocks wander in winter appears to be negatively correlated with the local abundance of pinyon pine cones. In areas outside the range of pinyon pines, much less is known about the diet of pinyon jays.

During the breeding season, pinyon jays deliver a wide variety of food to their nestlings. In northern Arizona, food delivered to nestlings was comprised of grasshoppers (37 percent), spiders (16 percent), butterflies (15 percent), beetles (12 percent), pine seeds (11 percent), flies (4 percent), and true bugs (2 percent; Bateman and Balda 1973). In New Mexico (Ligon 1978), the nestling diet included grasshoppers (33 percent), pine seeds (32 percent), butterflies (21 percent), beetles (7 percent), and spiders (4 percent). Balda (2002) noted that the diet of pinyon jays has not been studied over the large majority of the species' range.

Pinyon jays spend a majority of their foraging time on the ground (Balda et al. 1972), as evidenced by the high proportion of terrestrial food items in their diet (Balda 2002). During the late spring/early summer breeding period, pinyon nuts are normally harvested from cones on the ground, rather than from cones still on the tree (Balda 2002). Ligon (1978) suggested that caches of pinyon pine seeds were a critical resource for early nesting pinyon jays in New Mexico, as late snowfalls often reduced the birds to relying solely on seed caches for short periods of time.

### Breeding biology

#### *Courtship and pair formation*

Pinyon jays maintain long-term pair bonds, with separation of existing pairs being extremely rare (Marzluff and Balda 1988a, b). However, when one member of an established pair dies, a new pair bond typically forms quickly, irrespective of the time of year. Within established pairs, courtship behavior typically starts in November (at least in northern Arizona), although the timing of the onset of courtship is highly variable among years (Balda and Bateman 1972). One-year old birds may form pair bonds (usually with slightly older birds), but typically they do not breed until they are two years old. Pairs typically breed associatively by age, but pairs comprised of one-year old birds are very rare (Marzluff and Balda 1988b).

#### *Nest-site selection*

Aside from studies in ponderosa pine habitat in northern Arizona (Balda and Bateman 1972, Gabaldon 1978, Marzluff and Balda 1992), little is known about nest-site selection in pinyon jays. Nests are typically located in conifers, including pinyon pines, junipers, and ponderosa pine. In Arizona ponderosa pine forest, nests are often placed on the south side of trees, where exposure to solar energy is higher, but where prevailing southwest winds may lead to occasional nest destruction (Cannon 1973). Nests may be placed at varying heights in the nest tree, with an apparent tradeoff between predation and nest microclimate (Marzluff 1988). Nests near the tops of trees suffer higher depredation rates from American crows (*Corvus brachyrhynchos*) and common ravens (*C. corax*). However, high nests benefit from warmer microclimates, which may be a critical factor early in the breeding season (Cannon 1973).

Nest building takes place in mid-morning, with males typically carrying the bulk of the larger twigs

(e.g., Russian thistle [*Salsola kali*], gray rabbitbrush [*Chrysothamnus nauseosus*], and snake-weed [*Gutierrezia* spp.]; Balda and Bateman 1972) and both sexes collecting coarse grasses for the lining. The inner lining of the nest is composed of fine grasses, rootlets, hairs, and shredded bark, and the female performs most of the final lining of the nest (Balda 2002). In Arizona, construction of the nest took 7.3 days (Balda 2002).

### *Clutch and brood size*

Pinyon jays lay clutches of two to five eggs, with an average clutch size of 3.7 eggs in Arizona and New Mexico (Balda 2002). Clutch size does not appear to vary geographically and, surprisingly, does not appear to vary with parental age, at least in northern Arizona (Marzluff and Balda 1992). If nesting failure occurs early in the season, a replacement clutch is typically laid at a new, nearby site. Otherwise, in most areas second broods appear to occur very rarely, apparently only during situations when birds receive supplemental food from humans (Balda 2002). The exception to this pattern is in southwestern New Mexico (and likely adjacent areas of southeastern Arizona) where Ligon (1978) documented the occurrence of up to three breeding events by individual birds during a 12-month period. Ligon (1978) hypothesized that monsoon rains during late summer together with mild fall/winter weather allowed jays to breed repeatedly during years with bumper crops of pinyon seeds.

### *Parental care and offspring behavior*

Incubation is by the female only (only females have a brood patch), with the male partner providing food for the female throughout the incubation period. Measured rates of incubation feeding in Arizona averaged one feeding visit every 73 minutes, but they were much lower during periods of cold, winter-like weather (Marzluff and Balda 1992). Females apparently rarely leave the nest area during the incubation period. Incubation begins once the third egg is laid, leading to hatching asynchrony in clutches of four or five eggs. Studies in Arizona (Bateman and Balda 1973) and New Mexico (Ligon 1971) suggest an incubation period of 17 days.

Brooding is carried out by the female and is almost continuous for the first 10 days of the nestling stage. The young develop the ability to thermoregulate at about 12 days of age, but effective thermoregulation is enhanced by broodmates and thus the onset is earlier in larger broods (Bateman and Balda 1973). During the first 10 days of the nestling stage, the male provides the

female and nestlings with food. From day 10 onward, the female often accompanies the male on foraging bouts, and both parents deliver food to the young at an average of 1.3 feeding visits per hour (Marzluff and Balda 1992). This rate is low for a passerine bird, but likely results from the species' habit of carrying food in the expandable esophageal pouch (Marzluff and Balda 1992). Young typically fledge at about 21 to 22 days of age, at which point they are poor fliers and instead hide in nearby foliage. This early departure from the nest may be a response to the threat of predation at nest sites (Marzluff 1985). After fledging, young from the colony typically form a large group or "creche", which is typically accompanied by one or several adults.

At a small percentage of nests, a yearling male from the previous year's brood may assist the parents in caring for the brood. This assistance is limited to nestling care, including feeding, nest sanitation, and guarding. Helpers can provide significant amounts of food, accounting for an average of 30 percent of feedings at four nests monitored in Arizona (Marzluff and Balda 1990).

### *Nestling growth*

The only detailed study of nestling growth in pinyon jays was carried out in Arizona by Bateman and Balda (1973), and the information below was taken from that study. Nestlings hatch out naked, at an average mass of 6.26 grams. At ten days of age, nestlings average 54 percent of adult mass, and at fledging (21 to 22 days old), only 76 percent of adult mass. Body mass gain is most rapid from days 3 through 14, while wing feathers grow rapidly from day 8 to day 25. Nestlings are well-feathered dorsally by day 15, but still bare ventrally at that age.

### *Timing of breeding and breeding success*

Pinyon jays are relatively early breeders, with nests initiated in February in some years. However, the timing of breeding is highly variable, extending from early February until late April in Arizona. In the Black Hills of South Dakota, Peterson (1995) noted incubating females on 29 April, and a nest with eggs on 18 May. Johnsgard (1979) suggested that pinyon jays in the Black Hills bred from April to May, with dependent young seen from mid-April to mid-June. In Colorado, nests with eggs have been reported between 23 March and 19 May (Dexter 1998). There are no breeding dates available for Wyoming, aside from Knight's (1902) observation of fully fledged young in early June. In areas where the primary breeding habitat is pinyon-

juniper woodland, breeding may be stimulated by the presence of green cones on pinyon pines (Ligon 1974).

The only data on reproductive success come from Arizona and New Mexico. Marzluff and Balda (1992) suggest that the success of breeding in any year is the result of a complex interaction between the size of the cone crop, the age of the breeding cohort, late winter snowfall, predation pressure, and summer climate. Over many years in northern Arizona and central New Mexico, hatching success averaged 55 percent, fledging success averaged 56 percent, survival of fledglings through the crechling (i.e., late summer, post-breeding flocking) stage averaged 32 percent, and 41 percent of all birds that survived the crechling stage also survived their first winter (**Table 5**). Thus, approximately 5 percent of all eggs laid become yearling pinyon jays.

## Demography

### *Genetic characteristics and concerns*

Pinyon jays occur over a large portion of the interior western United States, but they are largely restricted to low-elevation conifer woodlands. Within Region 2, pinyon jay populations are patchily distributed, especially in Wyoming and South Dakota. Colony site fidelity is apparently strong, with dispersal typically limited in range (Marzluff and Balda 1989). Pinyon jays are known to occasionally wander widely in fall and winter, with a few records of individuals apparently having emigrated long distances (Balda 2002). Although the degree to which Region 2 pinyon jay populations are genetically linked is unclear, the lack of subspecific variation (range-wide) suggests a significant level of gene flow. Marzluff and Balda (1989) noted that because of dispersal to neighboring flocks, the effective population size in a given locality was the product of the geometry of the local flocks, where the size of the focal flock plus that of its immediate neighbors comprised the effective population. Genetic studies of population divergence among jays from the Black Hills, southern

Wyoming, and southeastern Colorado would give a good indication of the degree of genetic differentiation among jay populations in Region 2.

### *Life history characteristics*

The age at first breeding is variable, with most individuals breeding first when they are 2 years old, but with 10 percent of males and 3 percent of females breeding first when they are 3 years old (Marzluff and Balda 1992, Balda 2002). A small percentage (13 percent in northern Arizona) of all yearling males may assist their parents in raising a brood. This assistance occurs only during the nestling stage and primarily consists of delivering food, as well as cleaning and guarding the nest. Pairs with helpers do not show improved breeding success, and helping does not appear to directly benefit the helping bird (Marzluff et al. 1996). However, helping may allow inferior, subordinate males to gain experience that later allows them to perform better as adult breeders (Brown and Brown 1984, Marzluff et al. 1996). As Balda (2002) notes, nothing is known about the frequency of helping behavior in other parts of the species' range.

Aside from the deferred breeding of younger birds, there appears to be relatively little variation in reproductive success with age. Older birds often produce more fledglings, but the number of fledglings surviving their first year appears to be unrelated to parental age (Marzluff and Balda 1992). In addition, there is strong variation among years in the extent to which parental age affects breeding success (Marzluff and Balda 1992).

Survival of pinyon jays has been followed closely in northern Arizona (**Table 5**; Marzluff and Balda 1992). The surprising finding from this study is that survivorship of adults remains constant over most age classes, at about 74 percent, with no sign of increased survival, or of later senescence. In the wild, maximum longevity in Arizona has been measured at 16 years for

**Table 5.** Survival estimates of pinyon jays from the egg stage through adulthood. Data are from northern Arizona (Marzluff and Balda 1992).

State/age	Percentage of surviving
Egg to nestling	55
Nestling to fledgling	56
Fledgling to crechling	32
Crechling to yearling	41
Yearling to 2 years old	62
2 to 10 years old	74

males and 14 years for females, although most birds die when much younger (Marzluff and Balda 1992).

Analyses of life-cycle diagrams and their associated demographic matrices have been carried out for pinyon jays in northern Arizona (Marzluff and Balda 1992). Pinyon jay population growth appears to be much more sensitive to variation in survival rates than to variation in reproductive rates. In addition, male survival rates are consistently higher than female survival rates, apparently as a result of heavier female mortality during the breeding season. Calculations of pinyon jay population growth were carried out in three ways (see table 4 in Marzluff and Balda 1992). First, the net reproductive rate,  $R_0$ , was calculated as the total number of surviving offspring an individual will produce over its lifetime. For pinyon jays in northern Arizona, the calculated  $R_0$  was 0.59, a value well below 1.0 (population stability) and one that suggests that the flock under study was declining by 41 percent each generation. The second measure of population growth was lambda ( $\lambda$ ), calculated as the population size in year  $n$  divided by the population size in year  $n-1$ . Lambda was between 0.88 and 0.93, suggesting a decline of 7 to 12 percent each year. Finally, the intrinsic rate of natural increase,  $r$ , was calculated as:  $r = (\text{natural log of } R_0) / \text{generation time}$  where negative values of  $r$  indicate declining populations, positive values increasing populations, and 0 a stable population. For the flock under study in northern Arizona,  $r$  was -0.11, again indicating a declining population.

Marzluff and Balda (1992) noted that they did not see the expected strong drop in population size that their population growth analyses suggested. However, they pointed out that a key determinant of flock size is the rate of immigration. The known immigration rate (approximately seven yearling jays per year into a flock of 140 individuals) accounts for some (but not all) of the disparity in their results. They suggest that survival, especially for the younger age classes, may be slightly underestimated. Nonetheless, the analyses are suggestive of a long-term, local decline in population size.

Elasticity analyses (e.g. Caswell 2001) can be used to assess the relative importance of reproduction and survival for a given species. In Marzluff and Balda's (1992) study, elasticity analyses suggested that survivorship of young jays was the critical demographic trait buffering populations against environmental uncertainty.

The main results of their elasticity analyses were:

- ❖ survivorship of crechlings, one-year old and two-year old jays has the greatest impact on population growth
- ❖ relative to survivorship, fecundity played a small role in population growth
- ❖ the fecundity of young jays has a much larger impact on population growth than does the fecundity of older breeders

Further analyses suggested that mortality of young birds during the crechling stage was the most important source of mortality within the population.

### *Social patterns and spacing*

Pinyon jays are highly social birds, spending the entire year in flocks composed of family clans. Most juveniles remain in their natal flocks, with a small percentage emigrating to nearby flocks. Emigration is apparently driven by the sex ratio in the natal and nearby flocks (Marzluff and Balda 1989). In northern Arizona, the size of a single flock ranged from 121 to 292 members over a nine-year period, and largely depended on the number of juveniles produced during the preceding breeding season (Marzluff and Balda 1992). Within this same flock, the number of adults ( $\geq 2$  years old) was much more stable, ranging from 50 to 75 birds during the same period. Colony size typically decreases as the season progresses, with large colonies early in the year and smaller, satellite colonies (composed of failed breeders) later in the season (Marzluff and Balda 1992).

The size of the home range varies according to local food levels. During good food years in Arizona, the home range averaged 8 km<sup>2</sup>, but birds foraged up to 30 km away during poor food years (Balda 2002). Pinyon jays breed in loose colonies of approximately 100 ha in size, with nests spread evenly throughout the colony area. In Arizona, the average colony size was 11 nests, with a mean inter-nest distance of 110 m (Marzluff and Balda 1992).

Pinyon jays show relatively little aggressive behavior, with occasional threat displays (e.g., steps) towards conspecifics, and less often, fighting behavior (typically between males and during the fall; Balda 2002). At food sources, pinyon jays normally show little conspecific aggression, with flock members quietly foraging together in close proximity.

### *Factors limiting population growth*

As with most other sections of this report, the information available on factors limiting population growth are largely drawn from a single study in northern Arizona (Marzluff and Balda 1992, Balda 2002). That study was conducted in a suburban setting, and so many of the factors cited there may not be representative of more “wild” populations of pinyon jays.

Predation on eggs, nestlings, and crechlings can be a significant source of mortality within pinyon jay flocks. In Arizona, annual mortality of eggs and nestlings ranged from 5 to 60 percent (Marzluff and Balda 1992). During the nestling stage, the most common predators are American crows and common ravens while during the crechling stage, northern goshawks (*Accipiter gentilis*) and Cooper’s hawks (*A. cooperii*) are the principal predators (Marzluff and Balda 1992).

Pinyon jays occupy different habitats within (and outside) Region 2, and thus the factors that limit population growth likely vary geographically. In the Southwest (including Colorado), annual variation in the food supply (principally pinyon pine seeds) is likely the most important factor. The recent outbreak of pinyon engraver beetles, and the subsequent die-off of pinyon pine trees, is going to have long-term (>25 years) consequences for pinyon jay population growth in southern and western Colorado. In these same areas, pinyon jay populations have likely declined as a result of widespread clearing of pinyon-juniper woodlands, and due to an increase in predator (e.g., American crow, common raven) populations associated with human population growth in the region (Balda 2002).

In addition to pinyon die-off due to beetle infestation, large-scale fires in pinyon juniper habitats also represent a serious threat to pinyon jay populations. Pinyon pines are slow to colonize burned sites and also require at least 75 years to reach maximum cone production. Thus, in situations where fire consumes large areas of pinyon-juniper woodland, the recovery of such areas is likely to be a very slow process. While small-scale fires (including prescribed burns) may help to regenerate woodlands and provide for a range of age-structure within the woodland, large-scale fires will likely lead to the long-term abandonment of affected areas by pinyon jays.

In Wyoming and South Dakota, where pinyon jays occupy juniper and ponderosa pine woodlands, the factors limiting population growth are less clear. As is the case elsewhere in the range of pinyon jays, habitat

loss due to clearing and to fire is likely the primary threat to jays in these two states.

### *Community ecology*

Interactions between pinyon jays and their competitors and environment are summarized in **Figure 6**. The factor thought to be most important for pinyon jay population stability is the presence of mature pinyon-juniper, juniper, and ponderosa pine woodlands. Pinyon jays are heavily dependent on pinyon and ponderosa pine cone crops, and they will wander widely in search of such foods when they are not available within their home range. Human disturbance (e.g., urbanization, clearing of woodland) and drought are the two factors known to degrade the preferred nesting habitat, particularly in the southwestern portions of the pinyon jay’s range. Degradation/destruction of pinyon-juniper and ponderosa pine woodlands affects pinyon jays by eliminating nesting and roosting sites, and by eliminating the primary food resource (pine seeds) upon which pinyon jays depend during the winter months. Proximity of jay home ranges to urban areas appears to be a negative factor during breeding, when increased predator abundance (at least in Arizona) may lead to decreased breeding success. However, during winter, pinyon jays may benefit from access to seeds and other foods provided in suburban settings, particularly during periods of snowy weather.

As mentioned earlier, there are still virtually no published data on colony site/home range characteristics for pinyon jays in Region 2. Rather, most of the data on pinyon jay habitat affinities in Region 2 have come from BBS data, from Breeding Bird Atlas efforts (e.g., Kingery 1998), and from anecdotal information in regional publications (e.g., Pettingill and Whitney 1965). Thus, there is a clear need for studies quantifying habitat variables associated with pinyon jay nesting sites and foraging areas in Region 2 (see the Information Needs section).

Local habitat diversity may be an important factor affecting the availability of prey for pinyon jays. Pinyon jays consume a wide variety of prey types, especially during spring and summer (Balda 2002). Consequently, access to nearby grasslands, mesquite and sagebrush shrublands, forest openings, and other areas suitable for terrestrial foraging likely increases foraging success.

### *Predators and relationship to habitat use*

Predation on adult pinyon jays has rarely been observed. Higher mortality among breeding females

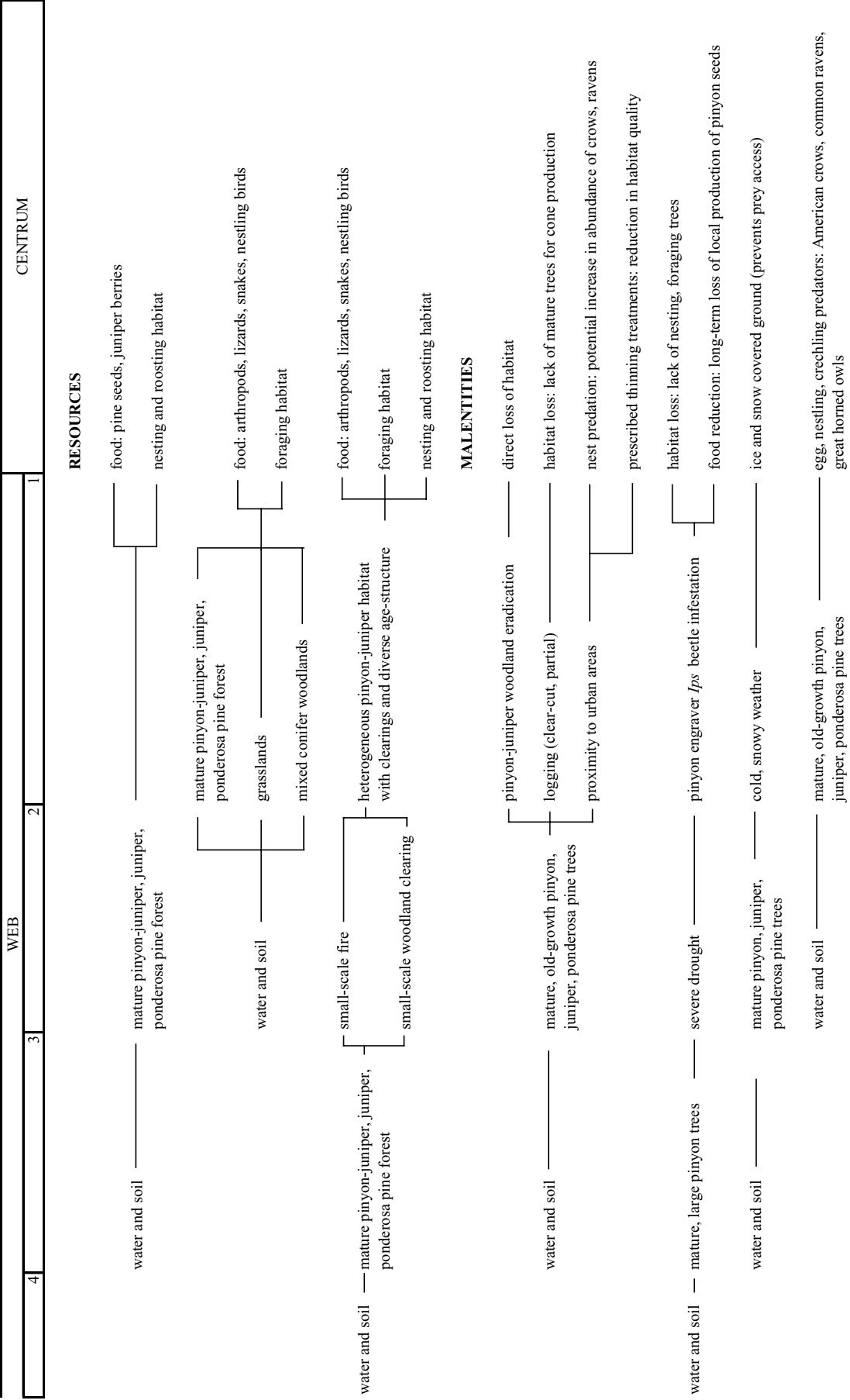


Figure 6. Envirogram representing the web of linkages between pinyon jays and the ecosystem in which they occur.

implies that females may face exposure to predators during the incubation stage (Marzluff and Balda 1992). Known predators include great horned owls (*Bubo virginianus*) and northern goshawks. These same predators (as well as Cooper's hawks) also take young jays, especially during the creche stage when juveniles are highly susceptible to predation. Predation of eggs and nestlings varies widely among years (5 to 60 percent of nests in Arizona; Marzluff and Balda 1992), but it is most often carried out by American crows and common ravens. Marzluff and Balda (1992) hypothesized that predation by corvids is greatly increased in areas where pinyon jays nest near humans, with crows and ravens being initially attracted to such areas by the presence of garbage. Other egg/nestling predators in Arizona have included bullsnakes (*Pituophis melanoleuca*), Steller's jay (*Cyanocitta stelleri*), Abert's squirrel (*Sciurus aberti*), rock squirrel (*Spermophilus variegatus*), coyote (*Canis latrans*), and gray fox (*Urocyon cinereoargenteus*). Ligon (1971) suggested that barn owls (*Tyto alba*), western scrub-jays, and bobcats (*Lynx rufus*) were probable predators in New Mexico.

### *Competitors*

Flocks of foraging pinyon jays are sometimes joined by Clark's nutcrackers (*Nucifraga columbiana*), Steller's jays, and western scrub-jays. However, the extent to which any direct competition occurs among these species is largely unknown. As western scrub-jays are unable to open green pine cones, they sometimes steal opened cones from foraging pinyon jays (Vander Wall and Balda 1981).

### *Parasites and disease*

Balda (2002) summarized the scant data on pinyon jay parasites and disease. There are no documented diseases and only a single known ectoparasite, a chewing louse *Philopterus phillipi* (Price and Hellenthal 1998). Blood-sucking fly larvae (presumed to be Calliphoridae) have also been noted at nests (Balda 2002).

## CONSERVATION

### *Threats*

The extent to which current land management activities in Region 2 are affecting pinyon jays is difficult to assess. Part of this uncertainty relates to the lack of knowledge concerning most aspects of pinyon jay ecology in the region. The only detailed studies of pinyon jays were carried out in central New Mexico

(Ligon 1978) and northern Arizona (Balda and Bateman 1972). In addition, there have been no studies of the effects of forest management practices on any aspect of pinyon jay ecology. As a consequence, parts of the discussion in this section are speculative and largely concerned with probable effects of land management activities on pinyon jays. Currently, the primary threats to pinyon jay population viability is a widespread die-off of pinyon pine in the southwestern United States, together with large-scale thinning of pinyon-juniper woodlands in an attempt to reduce fuel loads. While these problems will not threaten pinyon jay populations in South Dakota or Wyoming (areas north of the range of pinyon pine), they will have negative consequences for jay populations in Colorado.

### *Drought and Ips beetle outbreaks*

The primary natural disturbance that may negatively impact pinyon jays is drought. Long-term drought has been cited as the primary factor behind the recent outbreak of pinyon engraver beetles (*Ips confusus*) in the southwestern United States (Negrón and Wilson 2003). This outbreak has led to widespread mortality of pinyon trees, especially in the four-corners area, but also well into the southern portions of Region 2 (**Figure 4**). As this drought-induced beetle epidemic is likely to have serious negative effects on pinyon jays, this section will discuss the epidemic in some detail. Information on the biology of pinyon engraver beetles was largely taken from Wilson and Tkacz (1992), the Utah Division of Forestry, Fire and State Lands website (<http://www.ffsl.utah.gov/ID/pinyonengraverbeetle.pdf>), and Negrón and Wilson (2003).

Pinyon engraver beetles occur naturally in pinyon-juniper woodlands in the Southwest, but typically at relatively low levels. Under normal conditions, old, diseased, or otherwise stressed trees are the primary hosts for the beetles. Attacks by the beetles accelerate natural mortality and are often seen as a benefit to healthy pinyon-juniper woodlands as such mortality acts to thin woodlands, thereby improving growing conditions for the remaining trees. However, prolonged drought in the southwestern United States appears to have triggered water stress among pinyon trees, with a subsequent epidemic outbreak of beetles. It is thought that water stress increases the susceptibility of trees in two ways: 1) by reducing the production of sap, which under normal conditions is used to ward off attacks by beetles, and 2) by increasing nitrogenous compounds as well as sugar content in tree cells, both of which facilitate beetle development.

Pinyon engraver beetles damage pinyon trees largely by burrowing into the trees' conductive tissues, thereby restricting the transport of water and nutrients in the tree. Adults may also introduce a "blue stain" fungus that further reduces the capacity of the conductive tissue to transport water/nutrients. In most such cases, the tree eventually dies. Aside from water stress induced by drought, a high local density of pinyon trees is thought to be the primary factor acting to increase susceptibility to attack by pinyon engraver beetles. In addition, older and larger trees are preferred by the beetles, as are trees that host dwarf mistletoe infections. However, during periods of severe drought, a large majority of the local pinyon population may be attacked and killed, regardless of density or tree size/health. Pinyon engraver beetles normally overwinter as larvae at the base of infected trees. In spring, adults emerge and either infect another nearby tree, or fly about in search of uninfected trees. The adult lifecycle typically lasts six to eight weeks, with up to five generations of beetles produced in one season.

Although some mapping of the extent of the outbreak in Region 2 has occurred (**Figure 4**), no data have yet been published on the effects of the extensive pinyon mortality on the pinyon-juniper bird community. Clearly, pinyon jays are likely to be one of the most affected species, as they are heavily reliant on healthy pinyon cone crops. Although pinyon jays may switch to alternative food sources or shift home ranges, such behavior is typically in response to the short-term (but regular) loss of pinyon seeds as a primary food source. As pinyon pines are relatively long-lived and typically begin producing cones once they reach 25 years of age (Lanner 1981), the effects of the current epidemic are likely to be sustained over a long period. The effects of localized pinyon die-offs on jays may include shifts in colony sites/home ranges, increased fall/winter dispersal, higher mortality, and decreased breeding output. Other species that may be directly affected by the die-off include western scrub-jays, juniper titmice (*Baeolophus griseus*), bushtits (*Psaltiriparus minimus*), gray vireos (*Vireo vicinior*), and black-throated gray warblers (*Dendroica nigrescens*).

#### Loss and degradation of habitat

Pinyon-juniper woodlands have often been viewed as an exploitable resource with little conservation value (Johnson 1962, Johnson 1975). Balda (2002) noted that large swaths of pinyon-juniper habitat were eliminated (primarily for use as fuelwood and lumber, and also to enhance forage available for cattle grazing) in the southwestern United States from the 1860's

until the 1960's. From 1940 to 1960, state and federal agencies funded widespread pinyon-juniper eradication programs aimed at converting woodlands to livestock pastures (Terrel and Spillett 1975, Balda 2002). In Arizona alone, approximately 1.2 million acres of pinyon-juniper woodland were converted to grazing land between 1950 and 1964 (Arnold et al. 1964). Balda (2002) suggested that while no new policies have been enacted to preserve pinyon-juniper woodlands, in most cases, older (detrimental) policies are no longer followed. In some areas of the Southwest (e.g., northern New Mexico) pinyon pine is still widely collected for sale as firewood (D. Wiggins, personal observation), but the impact of such collection on birds and forest health is not known.

Human settlement and encroachment into pinyon jay habitat may not always be detrimental, as evidenced by the adaptation of some flocks to suburban areas of Flagstaff, Arizona (Marzluff and Balda 1992). Although direct loss of habitat occurs with human settlement, potential benefits include an increase in artificial food resources (Marzluff and Balda 1992). However, although pinyon jays are known to visit suburban bird feeders in Colorado during fall and winter, the extent to which Region 2 breeding birds utilize suburban habitats and exploit associated food resources remains unknown.

Efforts are underway by federal land management agencies to thin pinyon-juniper woodlands under the National Fire Plan (<http://www.fireplan.gov/>). Woodland thinning is focused on urban interfaces areas considered at risk to fire (typically within 1-2 miles of communities), where pinyon-juniper is currently being thinned at levels averaging a 70 percent reduction in crown cover (J. Burke, personal communication). In addition, dead and dying pinyon trees (as a result of the *Ips* infestation) are being removed. While the latter probably has little impact on pinyon jay ecology, the large reduction in the density of trees can have significant negative effects on local populations where the abundance of mature (cone-bearing) trees is reduced. As pinyon trees are relatively slow to mature, the loss of mature trees will have negative impacts over a long period.

#### Livestock grazing

Livestock grazing is a common feature in most pinyon-juniper woodlands in Region 2. The policy of removing pinyon-juniper woodland to promote grazing has resulted in significant habitat loss in several southwestern states (see the Loss and degradation of

habitat section above). As Balda (2002) noted, it is not clear to what extent removal of pinyon-juniper woodland is still being carried out specifically for the purposes of improving grazing for livestock. However, new regulations under the National Fire Plan have led to widespread (and intensive) thinning of pinyon-juniper woodlands. Extensive livestock grazing in southwestern riparian systems has been implicated as one of the major causes of declines in riparian obligate birds such as yellow-billed cuckoos (*Coccyzus americanus occidentalis*) and southwestern willow flycatchers (*Empidonax traillii extimus*). The potential effects of livestock grazing per se on pinyon jays are unclear, but degradation of grassland and riparian habitats and a consequent reduction in the local prey base are likely.

### Fire suppression

Fire suppression policies have led to widespread fuels build-up and have resulted in large-scale, severe wildfires in the western United States over the past decade, particularly in low to mid-elevation pine zones. These fires have been particularly frequent in the southwestern United States, including Colorado. As Balda (2002) noted, many thousands of acres of ponderosa pine forest in the southwestern United States had been severely burned since the late 1990's. The extent to which pinyon-juniper woodlands have also suffered from large-scale fires is less clear, but there have been a number of large fires in pinyon-juniper habitat in southern Colorado in the last decade. With sustained drought and widespread mortality in southern pinyon-juniper woodlands, severe wildfire in these habitats likely presents a threat to existing pinyon jay populations. However, the threat has recently been diminished somewhat in locations where thinning of woodlands has been accomplished in accordance with the National Fire Plan.

### ***Conservation Status of Pinyon Jays in Region 2***

Pinyon jays appear to be decreasing in abundance throughout Region 2, with recent strong declines apparent in Colorado and in South Dakota (**Table 4**). However, as noted elsewhere in this assessment, pinyon jays are not well-sampled by BBS or CBC methodology, and thus there is a degree of uncertainty regarding the population declines. Consequently, there is a clear need for a better understanding of the current population trends of pinyon jays in the region. There have been no historical shifts in distribution in Region 2, with the possible exception of northwestern Nebraska, where the current breeding status is unclear.

Irrespective of past population trends, Colorado pinyon jay populations may decline at very high rates in upcoming years as the effects of the current pinyon die-off become evident. One possible consequence of the die-off is that pinyon jays in southern and western Colorado may switch their habitat preference from pinyon-juniper to other habitats such as ponderosa pine or suburban woodlands. However, the ability of flocks to switch breeding habitats remains unknown. The status of pinyon jays in Wyoming is much less clear, as there are few quantitative data available on the distribution or population status of jays in that state. Similarly, the species' limited distribution in South Dakota hampers statistical analysis of BBS data. In addition, recent survey work on the Black Hills National Forest suggests that the majority of the pinyon jay population breeds just outside the boundaries of the national forest, on private land (A. Panjabi personal communication 2004b); this situation complicates data collection.

Habitats within Region 2 vary considerably in their ability to support breeding populations of pinyon jays. In Colorado, pinyon jays are largely restricted to pinyon-juniper woodlands in the southern and western portions of the state (**Figure 3**). Further north, they occur in similar transitional woodlands largely comprised of juniper and ponderosa pine (Pettingill and Whitney 1965, Scott 1993). Aside from the current outbreak of engraver beetles (see the Threats section above) that has killed and continues to kill pinyons over wide areas in southern and western Colorado, these woodlands are also susceptible to intense wildfires. Fire suppression policies and the subsequent outbreak of large, intense fires threaten most low-elevation pine habitats in Region 2. Drought has contributed to this problem in recent years, leaving forests dry, more heavily infested with engraver beetles and, as a result, increasingly prone to large-scale fire outbreaks.

The lack of information on the ecology of pinyon jays in Region 2 hampers our ability to assess their current conservation status. For example, as mentioned elsewhere in this assessment, the degree to which flocks are able to successfully breed after shifting home ranges (e.g., in response to fire, pinyon die-off, or other forms of habitat loss) is unknown. This is currently a critical question, as large portions of the species' preferred habitat are currently undergoing severe alteration as a result of pinyon die-off, as well as from intensive thinning efforts in some areas (primarily in southern and western Colorado, as well as adjoining areas of New Mexico and Arizona). As a consequence, there may be a large shift in the habitat association of pinyon jays in Colorado, from pinyon-juniper woodlands to higher

elevation ponderosa pine woodlands, or to breeding in more suburban situations as has occurred in northern Arizona (Matzluff and Balda 1992). Alternatively, if pinyon jay populations are unable to adapt to large-scale losses/alteration of their primary habitat, Region 2 may suffer significant declines in pinyon jay populations. In addition, the wholesale loss of pinyon-juniper habitat in the southwestern United States may lead to a decrease in immigration rates from populations immediately adjacent to Region 2. As discussed in the Information Needs section below, collection of baseline data on the species' ecology in Region 2 is critical to a better understanding of the conservation status of pinyon jays in this region.

### ***Management of Pinyon Jays in Region 2***

#### **Implications and potential conservation elements**

An important consideration in the management of pinyon-juniper habitat is the role that pinyon jays play in establishing and maintaining that habitat. Pinyon jays are the keystone species in pinyon-juniper woodlands, acting as the primary dispersal agent for pinyon seeds in and around existing woodlands. The habit of caching seeds in open areas with scattered trees and brush likely has the effect of expanding pinyon-juniper habitat into new areas or into areas that have been disturbed by fire, drought, or human disturbance (e.g., chaining). Thus, to some extent pinyon jays play a key role (or *the* key role) in establishing new areas of pinyon-juniper woodland and will likely be a key element in the re-establishment of pinyon-juniper woodlands in areas of southern Colorado (as well as New Mexico, Utah, and Arizona) affected by drought and *Ips* infestations.

Environmental effects on the abundance and distribution of pinyon jays in Region 2 are largely tied to habitat quality and the effects of drought, fire suppression, and destruction of pinyon-juniper and ponderosa pine woodlands. Managing for healthy, mature pinyon-juniper and ponderosa pine woodlands will likely be the single most effective means of supporting stable pinyon jay populations. While land managers have no control over drought and other weather phenomena, methods are available to reduce the risk of large, intense wildfires. Allowing small-scale, relatively cool fires (whether prescribed or wild) to burn may help to reduce local fuel loads as well as provide habitat diversity within stands of pinyon-juniper and ponderosa pine. While large-scale destruction and degradation (e.g., clearing, fire wood collection) of pinyon-juniper woodlands will likely

have negative consequences for pinyon jays, some small-scale (e.g., <20 acres) mechanical clearing may improve habitat by creating habitat diversity and reducing fuel loads within otherwise homogenous pinyon-juniper stands. For pinyon jays, the key to such habitat manipulations is to create a diversity of habitat structure at the landscape scale.

The extent to which the current thinning of pinyon-juniper woodlands (to reduce fuel loads) represents a threat to pinyon jays is also difficult to measure. The loss of mature, pine-bearing trees will reduce the local food supply and may also reduce the quality of such areas as breeding sites. Although such thinning may benefit pinyon jays over the long-term (ie., after 50-100 years) by increasing habitat diversity, the short-term effects are likely to be negative. However, given our lack of understanding of pinyon jay ecology in the region, the effects of thinning treatments on pinyon jay ecology are clearly a high priority for the regional conservation of the species (see the Information Needs section).

Once pinyon woodlands become affected by *Ips* beetle outbreaks, there are few alternatives available to counter the outbreak. Infested trees can be removed and burned, but this is probably not logistically possible except within localized outbreaks. Nearby, unaffected pinyon trees can be thinned to retard the spread of beetles, and insecticides can be sprayed on unaffected trees to prevent attack (Negrón and Wilson 2003). Again, however, such spraying will likely only be feasible in limited areas or to preserve individual trees.

Successful habitat management for pinyon jays in Region 2 will require further research on the species' ecology in the region. Currently, there is almost no information available on the species' ecology in Region 2, especially on colony site choice, philopatry, breeding ecology, and seasonal movement patterns (including foraging in alternative habitats and on alternative resources). Until such data are available, land management practices aimed at improving habitat for pinyon jays will have to be based on assumptions taken largely from studies conducted outside of Region 2.

#### **Tools and practices**

##### ***Inventory and monitoring***

To date, the only available large-scale data on pinyon jay population status come from BBS and CBC counts. Neither of these methods adequately samples pinyon jays, and thus a reliable census method

is lacking. Rather than conduct such random surveys for pinyon jays, a concentrated effort to locate and monitor pinyon jay flocks would provide more useful information at a lower level of effort. It is possible that dedicated searches for pinyon jay flocks within known areas of occurrence may provide an adequate long-term indication of population change.

Ligon (1978) and Marzluff and Balda (1992) showed that pinyon jay flocks tend to nest repeatedly in the same general areas within their home range. As a consequence, long-term breeding site monitoring may provide a good measure of population status, with a minimum of research effort. Such monitoring could be relatively easily accomplished once home ranges and colony sites have been identified (see the Information Needs section). A general census/population monitoring scheme would ideally include:

- ❖ mapping the locations of pinyon jay flocks using Global Positioning System (GPS) technology
- ❖ characterizing habitat within known home ranges using Geographic Information System (GIS) methods
- ❖ conducting annual or semi-annual counts of flock size, preferably during late winter/spring
- ❖ capturing a sub-sample of birds within each flock, using methods such as cannon-netting
- ❖ extrapolating information on habitat and flock size to arrive at landscape-scale estimates of population size

These techniques are outlined further in **Table 6**. Most of the necessary data could be collected during or just after point counts (along transects in suitable habitat) in spring, thereby simplifying data collection. Habitat characteristics that may be important include the density of pinyon and juniper, some indication of age structure of the local woodland, grass and shrub height, and grazing pressure.

At times, the USFS has used the pinyon jay as a Management Indicator Species; until recently it was a MIS on the Grand Mesa and Uncompahgre and Gunnison national forests. Balda (2002), however, suggests that the species is a poor candidate for an indicator species because it is difficult to accurately assess population status. Bird surveys in pinyon-juniper woodlands in western Colorado appear to support this notion as pinyon jay flocks are often missed on point counts (R. Lambeth personal communication 2004).

#### *Habitat management*

No habitat management approaches have been developed for pinyon jays. The recent breeding bird atlas surveys in Colorado (Kingery 1998) and in South Dakota (Peterson 1995) have provided a good picture of the species' general breeding distribution in those states, but more detailed data on nesting habitats are needed throughout Region 2 (especially in Wyoming). Such data could be collected during home range surveys (see above) and would allow land managers to begin developing habitat management plans for pinyon jays.

A recent publication (Gillihan 2005) centering on the management of pinyon-juniper woodlands for birds suggested the following management techniques for pinyon jays:

**Table 6.** Proposed census and population monitoring techniques for breeding pinyon jays.

<b>Census/monitoring goal</b>	<b>Methods</b>
Location of breeding flocks	<ul style="list-style-type: none"> <li>❖ 5-minute point counts along off-road transects in suitable breeding habitat.</li> <li>❖ Census period March-June.</li> <li>❖ GPS readings for each flock location.</li> </ul>
Size of breeding flocks	<ul style="list-style-type: none"> <li>❖ Careful counts of the number of individuals observed during point counts.</li> </ul>
Composition/stability of flocks	<ul style="list-style-type: none"> <li>❖ Capture and color-band flock members.</li> <li>❖ Cannon-netting or similar technique.</li> </ul>
Habitat use	<ul style="list-style-type: none"> <li>❖ Characterize habitat at points identified during census and at any nesting sites.</li> <li>❖ Enter data in GIS.</li> </ul>
Landscape-scale population size	<ul style="list-style-type: none"> <li>❖ Extrapolation (using GIS) of estimated flock size and habitat use data to population size.</li> </ul>

- ❖ retain patches of mature pinyon or pinyon-juniper of *greater than 7 square miles* (18 km<sup>2</sup>), which is likely near the minimum area of each flock's home range (Ligon 1971, Balda and Bateman 1972)
- ❖ retain large trees, which are the most prolific cone-producers, since successful breeding is very closely tied to pinyon pines and seed production
- ❖ inventory potential breeding habitat on an annual or biannual basis to locate nesting sites
- ❖ develop roads, picnic areas, or other sources of disturbance no closer than 0.6 miles (1 km) from known nesting sites since pinyon jay breeding colonies are sensitive to human disturbance

With respect to the thinning of pinyon-juniper woodlands in Region 2 and adjacent areas, there are several techniques that may help to reduce the negative impacts on pinyon jays. First, thinning is typically carried out without regard to the species (i.e., pinyon vs. juniper) or age of trees. Attempts should be made to leave a thinned woodland that maintains mature, cone-producing pinyon trees. This could be achieved either by targeting younger pinyons, or by preferentially thinning juniper. However, thinning juniper may have negative effects on other species (e.g., black-throated gray warbler, gray vireo) that are closely tied to pinyon-juniper habitats.

### ***Information Needs***

The primary information needed for effective conservation of pinyon jays in Region 2 is a clearer picture of how the species responds to alterations in habitat. Currently, two forms of habitat change, pinyon die-off due to drought-induced *Ips* beetle attacks and clearing/thinning of pinyon-juniper woodlands, are likely having significant negative effects on population viability of pinyon jays. However, pinyon jays are not well-sampled with standard surveying methodology, making population status difficult to determine. Thus, an accurate method to census for pinyon jays needs to be developed. The high mobility of this species makes surveying difficult during the fall and winter, when large-scale movements are most frequent. Instead, breeding season (February-May) surveys would likely provide the most useful and rigorous data on population status. Within the National Forest System,

permanent survey transects should be established in known areas of jay activity (ideally in areas where nesting is known to occur), typically in pinyon-juniper or pinyon-juniper/ponderosa pine transition zones in Colorado, and in juniper/ponderosa pine in Wyoming and South Dakota. Surveys carried out three or four times each year during April and May would likely give the best results. Once colony sites/home ranges are identified, they should be monitored every year to assess how many pairs are nesting, and when possible during later visits, to assess reproductive success (e.g., by counting the sizes of creches).

Particularly valuable information on habitat/resource use could be gained by capturing and marking a few birds in several local flocks. Capturing (e.g., cannon-netting at watering or feeding sites) and banding a subset of individuals in each flock would also help to clarify flock movements and dispersal across the landscape. In addition, attaching radio collars to two or three flock members would provide a wealth of information on local habitat use and simplify locating the breeding colony.

There is currently little information on how pinyon jays respond to fine-scale and broad-scale changes in habitat. Rather, the links between habitat management and jay population status are hypothetical and based upon known or presumed effects of habitat management on foraging and nesting habitat. Gathering data on the effects of management practices and natural disturbances on pinyon jays can best be carried out by monitoring known and potential colony sites, by assessing flock size and reproductive success, and by relating these results to local habitat management activities (e.g., large-scale loss of local pinyon trees, thinning of pinyon-juniper woodland). At some subset of colony sites data should be collected on the abundance of the pinyon crop, and these data should then be analyzed with respect to any local changes in reproductive success. As noted by Balda (2002), reproductive success of pinyon jays is affected by a complex suite of factors, and thus experiments likely represent the most promising method of determining the effects of local habitat management. As such, detailed studies of the factors influencing reproductive success are likely to be labor intensive and would consequently best be pursued by graduate students or independent researchers.

For pinyon jays breeding in Region 2, there is little information on the location of breeding colonies, how stable such colonies are over time, and what factors promote birds to shift colony sites. In fact, outside of

data collected during studies in Arizona and New Mexico, there remains very little published information on any aspect of pinyon jay ecology. As pinyon jay ecology (e.g., habitat use) can vary geographically, it is important to collect baseline data on colony site choice, reproductive success, philopatry and food habits within Region 2. A large percentage of the information in this assessment has come from studies of a single large flock in northern Arizona (Marzluff and Balda 1992), where jays were breeding in a suburban setting. As a consequence, the ecological setting in the Arizona study may not be representative of the situation over much of the species' range. For example, Balda (2002) pointed out that predation on eggs, nestlings, and adults was likely much higher in the Arizona study area than in other areas, largely as a result of the increase in crow and raven abundance around human habitations.

Wherever possible, detailed studies of reproductive ecology would help to establish whether

Region 2 populations are similar to those studied in Arizona and New Mexico. Data on nest site characteristics and the distribution of nests within the colony, reproductive success, home range size, and site fidelity would provide useful information for land managers. Especially during the current pinyon die-off in southern Colorado, studies of pinyon jay reproductive ecology in areas that have not yet been affected by the die-off would be particularly informative. Finally, understanding the response of pinyon jay populations to the widespread thinning of their woodland habitat would be extremely useful for land managers. In particular, data on how birds respond to differences in thinning treatments (e.g., % of trees removed, age of trees removed, species of tree removed) would give land managers a better idea of how the modification of current thinning practices may create more desired landscape conditions for pinyon jays.

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